PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Commissioner
US Department of Commerce
United States Patent and Trademark
Office, PCT
2011 South Clark Place Room
CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing: 11 January 2001 (11.01.01)	
International application No.: PCT/EP00/05098	Applicant's or agent's file reference: D.BHATOOLAUL4
International filing date: 02 June 2000 (02.06.00)	Priority date: 02 July 1999 (02.07.99)
Applicant: BHATOOLAUL, David, Lahiri et al	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International preliminary Examining Authority on:

11 November 2000 (11.11.00)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer:

J. Zahra

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PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

6

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
D.BHATOOLAUL4-16		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/EP00/05098	02/06/2000	02/07/1999
International Patent Classification (IPC) or national classification and IPC H04B1/707		
Applicant LUCENT TECHNOLOGIES INC.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 6 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 10 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☒ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
11/11/2000	29.06.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Kolbe, W Telephone No. +49 89 2399 8479

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/EP00/05098

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:
Description, pages:

2-6,10,11,14,15	as originally filed			
1,1A,7-9,12,13	as received on	13/03/2001	with letter of	09/03/2001

Claims, No.:

1-11	as received on	13/03/2001	with letter of	09/03/2001

Drawings, sheets:

1/6-6/6	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-11
	No:	Claims	
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-11
Industrial applicability (IA)	Yes:	Claims	1-11
	No:	Claims	

2. Citations and explanations
   see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

Re Item V

Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Reference is made to the following documents:

   D1: EP-A-0 795 969 (MATSUSHITA ELECTRIC IND CO LTD) 17 September 1997 (1997-09-17)
   D2: DATABASE WPI Section EI, Week 199920 Derwent Publications Ltd., London, GB; Class W02, AN 1999-239899 XP002124380 & JP 11 068700 A (NEC CORP), 9 March 1999 (1999-03-09)
   D3: ABETA S ET AL: 'PERFORMANCE COMPARISON BETWEEN TIME-MULTIPLEXED PILOT CHANNEL AND MOBILE RADIO. PARALLEL PILOT CHANNEL FOR COHERENT RAKE COMBINING IN DS-CDMA' IEICE TRANSACTIONS ON COMMUNICATIONS,JP,INSTITUTE OF ELECTRONICS INFORMATION AND COMM. ENG. TOKYO, vol. E81-B, no. 7, page 1417-1425 XP000790175 ISSN: 0916-8516

2. Document D1, see in particular the passages cited in the International Search Report, discloses

   a method of providing pilot symbols in a code division multiple access mobile radio channel communications network comprising the steps of
   (a) providing a first set of pilot symbols through a plurality of pilot channels (symbols 108 in the communication channels), each such channel being dedicated to one mobile user;
   (b) simultaneously providing a second set of pilot symbols through one common control channel (the pilot channel 101); and
   (c) combining the first and second sets of pilot symbols in a mobile station (the coherent detection is effected with the first set of pilot signals from the communication channel in combination with the pilot symbols from the pilot channel, see Figure 5 illustrating the structure of a mobile station and column 8, lines 30-47 of D1)

The method according to claim 1 only differs from this known method in that it further comprises the step of

(d) estimating from said combination the channel impulse response.

In order to attain an accurate channel estimate, it is however known to combine pilot symbols of different channels. This problem and its solution, by combining several pilot symbols of different channels for channel estimation is known from document D2, see whole abstract.

A skilled person, having the problem to improve the accuracy of the channel estimate in a system known from D1, would therefore apply the teaching of D2 which clearly suggests to combine pilot signals of different channels for that purpose and by following this suggestion he would arrive at the subject matter of claim 1 without the exercise of an inventive step, Article 33(3) PCT.

3. The subject-matter claimed by independent claims 7 and 10 corresponds to the subject-matter claimed in claim 1, hence, the above argumentation under point 2 correspondingly applies to these claims.

4. Dependent claims 2 to 6, 8,9, 11 do not contain any additional features which, in combination with the features of any claim to which they refer, involve an inventive step (Article 33(3)) since these claims merely define an association of known features functioning in their normal way and, in combination, not producing any non-obvious working interrelationship, cf. Guidelines Chapt. IV,8.8(B1).

Re Item VIII

Certain observations on the international application

Although claims 1, 7, 10 have been drafted as separate independent claims, they appear to relate effectively to the same subject-matter and to differ from each

other only with regard to the definition of the subject-matter for which protection is sought and in respect of the terminology used for the features of that subject-matter. The aforementioned claims therefore lack conciseness.

Hence, claims 1, 7,10 do not meet the requirements of Article 6 PCT.

CODE DIVISION MULTIPLE ACCESS SYSTEM HAVING IMPROVED PILOT CHANNELS

This invention relates to a code division multiple access (CDMA) system , especially a wide band or direct sequence (DS) CDMA system, and relates particularly to the arrangements for providing pilot channels.

For effective use of direct sequence CDMA systems for digital mobile cellular telephone and personal communication network applications, a detection technique must be used which performs well at low signal to interference ratios. Coherent detection is preferred to non-coherent detection because it has better performance in the slow fading environments which typify personal communication channels. To apply coherent detection, the channel impulse response at a receiver must be known, and this can be achieved by transmitting pilot symbols.

In EP 0 795 969 Matsushita, in a CDMA cellular radio transmission system, the pilot channel can be transmitted with a low power because the pilot channel is multiplexed in the base station with pilot symbols inserted in signals in communication channels but there is no provision of a dedicated pilot channel for each user.

In Database WPI Section E1, Week 1999 20, Derwent Publications Limited JP11 068 700 NEC; 9th March 1999, there is disclosure of assigning predetermined pilot symbols for a corresponding physical channel. Channel estimation accuracy is enhanced, but there is no power reduction.

In IEICE trans.commun.volume E81-B 7 July 1998, Abeta et al, the BER performances of two types of pilot channel-based coherent Rake combining are compared but there is no discussion of other channel types.

Pilot symbols can be transmitted in two ways; a) a dedicated pilot channel, i.e. one pilot channel for each user, in which pilot symbols are embedded periodically (time – or code-multiplexed) in the same channel as the data symbols, or b) a common pilot channel, i.e. one pilot channel for all

Figure 10 shows in more detail one of the base stations of Figure 7, operating according to the invention.

In Figure 7 a wireless telecommunication system 10 comprises a number of mobile stations (MS) 11,12,13,14 and a number of base transceiver stations N node B 15,16,17,18 connected through a radio network controller (RNC) 19,20 (all in the radio access network RAN 21) to a core network (CN) 22. The CN is connected to the public switched telephone network PSTN 23.

In Figure 7, each mobile 12 is provided with a dedicated pilot channel which carries pilot symbols to the mobile; the mobile uses these symbols to determine the extent of some of the key radio channel effects on desired transmitted signal to the mobile.

Examples of these radio channel effects are:

i) Offset in frequency due to the well known mobile radio channel Doppler effect;

ii) Offset in timing synchronisation die to multipath propagation;

iii) Energy loss in the transmitted signal due to propagation loss and fast-fading induced by multipath propagation.

With a knowledge of the extent of key radio channel phenomena the mobile can configure the various functions/processes/schemes that demodulate the received signal, such as the timing and tracking synchronisation and channel estimation, to minimise the distortion caused by radio channel phenomena. In addition, the mobile can provide feedback to the network, suggesting means to vary certain characteristics of its downlink reception and demodulation.

In the system illustrated in Figure 7, as is well known, there are a number of common control channels in the downlink which are commonly broadcast by the network; such channels typically include a broadcast channel BCH, a forward access channel FACH and a paging channel PCH.

The BCH is used to provide cell-specific information, such as the cell identity and the available short and long codes for random access channel RACH transmission; information about neighbouring cells can also be provided. In the majority of cell scenarios the information carried by the BCH

can be assumed to be static for the duration of most telephone calls.

The FACH is primarily used to carry initial call set-up control information to a mobile when the system knows the location cell of the mobile. The FACH can also carry short intermittent packet information.

The PCH is used to carry information primarily to initiate network originated calls, eg from a landline telephone, to a mobile station when the system does not know the location cell of the mobile. The PCH may have a ※sleep mode※ when traffic is low.

These and other common control channels are separated from one another by channelisation codes, and possibly also by fixed time-offsets.

In the arrangement there is no common pilot channel, therefore each channel in addition has its own dedicated pilot symbols which are embedded at regular intervals between the transmitted data symbols.

control channels such as the BCH, FACH and PCH. Since all the channels experience the same channel conditions, the mobile can obtain accurate and robust multi-path tracking information, as well as channel estimates.

The energy flow arrangement illustrated in Figure 8 applies when there is a non-zero offset between the two sets of pilots; the parallel receiver structure allows the two sets of pilot symbols to be demodulated in parallel.

If there is no time offset between the two sets of pilot symbols, parallel pilot symbol energy flows such as illustrated in Figure 8 will not be necessary, and a sub-set of existing rake fingers can be allocated to demodulate just the multipath components which are deemed to require extra robust ※ channel estimation※ ; this requires additional rake finger management.

A typical mobile 12 is shown in Figure 9. It has a RF transceiver 50 connected to a baseband demodulator 52 which passes control data to a control signal processor 54 and data signals to a decoder connected to a user data processor 58.

A further reduction in pilot energy can be achieved by incorporation of base station (BTS) intervention. The mobile 12 is arranged to provide feedback signals to the BTS about the quality of its HCPCH, ie the noise or power or phased rotation of the pilot symbols. The BTS can then reduce the power of the pilot symbols in the mobile's dedicated pilot channel in comparison with the power of the data symbols. A further advantage of such a power variation is that, depending on the cell scenario, it will reduce the overall power transmitted by a BTS on the downlink, which for a multi-user CDMA system (Fig.7) improves the downlink capacity.

To provide BTS intervention, additional parts of the mobile 12 are affected; referring to Figure 9, the control data processor provides the required information to the BTS by a loop to the base band demodulator 60 in the mobile, its output being connected to the RF transceiver 50.

A yet further improvement is provided by adapting one of the common channels, using the BTS intervention arrangement described above. The channel and tracking estimation stages, 34, 36 in Figure 8, are arranged to estimate the performance gains from the HCPCH; this performance gain can be improved by adapting the time-offsets between the pilot symbols belonging

Claims

1. In a code division multiple access mobile radio channel communications network, a method of providing pilot symbols comprises providing a first set of pilot symbols through a plurality of pilot channels (30), each such channel being dedicated to one mobile user; simultaneously providing a second set of pilot symbols through at least one common control channel (38); and in a mobile (11, 12, 13, 14) combining the first and second sets of pilot symbols and from said combination estimating the channel impulse response.

2. A method according to claim 1 in which the common channel is one of a broadcast channel or a forward access channel or a paging channel.

3. A method according to claim 1 or claim 2 in which the pilot symbols from all common channels are combined.

4. A method according to any preceding claim further comprising combining static data transmitted on at least one of the common channels with the first and second sets of pilot symbols.

5. A method according to any preceding claim comprising transmitting from a mobile to a network base station information relating to quality of received pilot symbols, the base station then varying the energy associated with the first set of pilot symbols supplied to that mobile.

6. A method according to claim 5 further comprising the step of varying the time offsets between the radio frames in the dedicated pilot channel and at least one common channel.

7. A code division multiple access mobile radio telecommunications network (10) comprising a plurality of mobiles (11, 12, 13, 14) each having a dedicated pilot channel; a plurality of base stations (15, 16, 17, 18); first pilot symbol generation means arranged to supply pilot symbols to the dedicated pilot channels; second pilot symbol generation means arranged to supply to at least one common control channel dedicated pilot symbols embedded between data symbols broadcast by the common control channel; and in each mobile, receiving means (50, 32, 40) arranged to receive pilot symbols in the dedicated pilot channel and the common control channel, combining means to combine the received pilot symbols, channel estimation means (34, 36) to receive the combined pilot symbols, and coherent detection means (54) arranged to vary at least one property of the mobile in accordance with the output of the channel estimation means.

8. A network according to claim 7 in which each mobile (11, 12, 13, 14) is arranged to send to an associated base station (15, 16, 17, 18) information relating to the quality of pilot symbols received on its dedicated pilot channel, and each base station is arranged to vary the energy of said pilot symbols accordingly.

9. A network according to claim 8 in which each mobile (11, 12, 13, 14) is further arranged to send to an associated base station (15, 16, 17, 18) information relating to the quality of pilot symbols received on the at least one common channel, and each base station is arranged to vary the time-offsets between radio frames of the dedicated traffic channel accordingly.

10. A mobile (11, 12, 13, 14) for use in a code division multiple access radio telecommunications network (10) comprising first receiving means (50, 32) to receive pilot symbols on a dedicated pilot channel (30); second receiving means (50, 40) to receive pilot symbols on at least one common channel (38); combining means to combine said pilot symbols; and channel estimation means (34, 36) connected to the combining means to provide an output to coherent detection means (54).

11. A mobile according to claim 10 further comprising a set of rake fingers (32, 40) arranged to receive the combined pilot symbols.

PATENT COOPERATION TREATY

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INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION** see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
D.BHATOOLAUL4		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/EP 00/ 05098	02/06/2000	02/07/1999
Applicant		
LUCENT TECHNOLOGIES INC.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language,** the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 8

   [X] as suggested by the applicant.

   [ ] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No
PCT 00/05098

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04B1/707 H04B7/005 H04L25/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04B H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 795 969 A (MATSUSHITA ELECTRIC IND CO LTD) 17 September 1997 (1997-09-17) abstract column 3, line 41 -column 4, line 26 column 5, line 21 - line 56 column 8, line 8 - line 47 ---	1,7,10
A	DATABASE WPI Section EI, Week 199920 Derwent Publications Ltd., London, GB; Class W02, AN 1999-239899 XP002124380 & JP 11 068700 A (NEC CORP), 9 March 1999 (1999-03-09) abstract --- -/--	1,7,10

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
2 October 2000	19/10/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Lustrini, D

2

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International Application No
PC[redacted]00/05098

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	ABETA S ET AL: "PERFORMANCE COMPARISON BETWEEN TIME-MULTIPLEXED PILOT CHANNEL AND MOBILE RADIO. PARALLEL PILOT CHANNEL FOR COHERENT RAKE COMBINING IN DS-CDMA" IEICE TRANSACTIONS ON COMMUNICATIONS,JP,INSTITUTE OF ELECTRONICS INFORMATION AND COMM. ENG. TOKYO, vol. E81-B, no. 7, page 1417-1425 XP000790175 ISSN: 0916-8516 abstract paragraph '0003! ---	1,7,10, 11
A	US 5 862 453 A (LOVE ROBERT T ET AL) 19 January 1999 (1999-01-19) abstract column 2, line 14 -column 3, line 21 -----	5,8

2

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT 00/05098

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0795969 A	17-09-1997	JP 2934185 B	16-08-1999
		JP 9252266 A	22-09-1997
		CN 1165460 A	19-11-1997
		DE 69702875 D	28-09-2000
		EP 1028541 A	16-08-2000
		US 6028852 A	22-02-2000
JP 11068700 A	09-03-1999	NONE	
US 5862453 A	19-01-1999	US 5771461 A	23-06-1998
		BR 9706569 A	20-07-1999
		CN 1196846 A	21-10-1998
		EP 0852852 A	15-07-1998
		JP 11512273 T	19-10-1999
		WO 9800928 A	08-01-1998

CODE DIVISION MULTIPLE ACCESS SYSTEM HAVING IMPROVED PILOT CHANNELS

This invention relates to a code division multiple access (CDMA) system, especially a wide band or direct sequence (DS) CDMA system, and relates particularly to the arrangements for providing pilot channels.

For effective use of direct sequence CDMA systems for digital mobile cellular telephone and personal communication network applications, a detection technique must be used which performs well at low signal to interference ratios. Coherent detection is preferred to non-coherent detection because it has better performance in the slow fading environments which typify personal communication channels. To apply coherent detection, the channel impulse response at a receiver must be known, and this can be achieved by transmitting pilot symbols.

Pilot symbols can be transmitted in two ways; a) a dedicated pilot channel, i.e. one pilot channel for each user, in which pilot symbols are embedded periodically (time- or code-multiplexed) in the same channel as the data symbols, or b) a common pilot channel, i.e. one pilot channel for all

users, in which pilot symbols are continuously sent on a separate channel in parallel with data channels.

An advantage of dedicated pilot channels is that power can be varied, so that a mobile at a boundary of a cell can ramp up the power of its received symbols to overcome channel propagation as well as fast fading; however the system relies on good ▒ statistical multiplexing▒ of users to ensure that there is always spare transmitter capacity to meet a sudden demand from a mobile for increased power, which can create instability.

The well known differences between the two arrangements will now be described with reference to figures 1-6.

Figure 1a shows the sector coverage angle alpha (e.g. 30° to 40°) over which a small base station transmits. Figure 1b indicates by the enclosed area the energy E_d required to transmit data, and this is assumed to be constant. Figure 1c indicates by the shaded area the energy E_p required to transmit pilot symbols in either a dedicated pilot channel or a common pilot channel.

Figure 2 illustrates energy requirements in a common pilot channel arrangement, and is effectively a merger of figures 1b and 1c; a single continuous pilot channel is broadcast to all users.

Figure 3 illustrates energy requirements in a dedicated pilot channel arrangement; each of the N users (where N = 5) has a different energy requirement E1 to E5, shown by the shaded and crosshatched areas. The total energy requirement for the pilot channels is $N*E_p$. This arrangement assumes there is no power control facility to vary power transmission.

Figure 4 shows a variation of figure 3 including a power control facility. The power supplied to each pilot channel can be controlled individually, as indicated by the different areas of the shaded and crosshatched bands E6 to E10. At certain times, in theory, the pilot in a channel can even be switched off completely, saving energy, and allowing other data or control information to be transported by that channel. Pilot energy requirement is $\Sigma E_{p,i} \bullet \beta_i$ where β_i is the scaling factor for each user, dependant on power control and time multiplexing. β is between 1 and 0, i.e. it is small when a mobile is close to its base station.

However comparison with figure 1c shows that the total power used is unchanged.

Figure 5 indicates energy requirements where spatially adaptive antennas are used. Data energy is transmitted in much narrower sections $\alpha 1$ to $\alpha 4$ within the sector angle α, i.e. a beam forming technique is used. The narrow sectors $\alpha 1$ to $\alpha 4$ are directed towards active mobiles, and the pilot energy required for each narrow sector is also varied in accordance with need, as indicated by the shaded areas. The total energy requirement is greatly reduced. The pilot energy requirement is $\sum_{i}^{N} \beta_i E_p G_A$ where G_A is the gain of the directed antennas.

Figure 6 shows that, in addition to the directed channels of figure 5, some common channel facility is required across the whole sector angle α, e.g. for mobiles attempting to make a call, and the data power for this is indicated at E_{dc}, between the directed sectors with the associated pilot energy indicated by the cross-hatched areas E_{pc}. Pilot energy requirements are $\sum_{i}^{N} \beta_i E_p G_A + \sum_{i}^{C} \beta_i E_p$, where C is the number of common channels.

It is the object of the invention to provide a pilot channel arrangement having reduced energy requirements.

According to the invention in a code division multiple access mobile radio telecommunications network, a method of providing pilot symbols comprises providing a first set of pilot symbols through a plurality of pilot channels, each such channel being dedicated to one mobile user; providing a second set of pilot symbols through at least one common control channel; and in a mobile combining the first and second sets of pilot symbols and providing said combination to channel impulse response sensing means.

In effect the common pilot energy $\sum_{i}^{c} \beta_i E_p$ is used by a mobile in addition to pilot energy provided on its dedicated pilot channel.

The common control dowmlink channel may be a broadcast channel or a forward access channel or a paging channel.

Also according to the invention a code division multiple access mobile radio telecommunications network comprising a plurality of mobiles each having a dedicated pilot channel; a plurality of base stations; first pilot symbol generation

means arranged to supply pilot symbols to each dedicated pilot channel; second pilot symbol generation means arranged to supply to at least one common control channel dedicated pilot symbols embedded between data symbols broadcast by the common control channel; and in each mobile receiving means arranged to receive pilot symbols in the dedicated pilot channel and the common control channel, combining means to combine the received pilot symbols, channel estimation means to process the combined pilot symbols, and coherent detection means arranged to vary at least one property of the mobile in accordance with the output of the channel estimation means.

The invention will now be described by way of example with reference to Figures 7 to 10 in which:-

Figure 7 is a schematic drawing of a DS CDMA network;

Figure 8 indicates the energy extraction process in a method according to the invention;

Figure 9 shows in more detail one of the mobiles of Figure 7, operating according to the invention; and

Figure 10 shows in more detail one of the base stations of Figure 7, operating according to the invention.

In Figure 7 a wireless telecommunication system 10 comprises a number of mobile stations (MS) 11,12,13,14 and a number of base transceiver stations N node B 15,16,17,18 connected through a radio network controller (RNC) 19,20 (all in the radio access network RAN 21) to a core network (CN) 22. The CN is connected to the public switched telephone network PSTN 23.

In Figure 7, each mobile 12 is provided with a dedicated pilot channel which carries pilot symbols to the mobile; the mobile uses these symbols to determine the extent of some of the key radio channel effects on desired transmitted signal to the mobile.

Examples of these radio channel effects are:

i) Offset in frequency die to the well known mobile radio channel Doppler effect;

ii) Offset in timing sunchronisation die to multipath propagation;

iii) Energy loss in the transmitted signal due to propagation loss and fast-fading induced by multipath propagation.

With a knowledge of the extent of key radio channel phenomena the mobile can configure the various functions/processes/schemes that demodulate the received signal, such as the timing and tracking synchronisation and channel estimation, to minimise the distortion caused by radio channel phenomena. In addition, the mobile can provide feback to the network, suggesting means to vary certain characteristics of its downlink reception and demodulation.

In the system illustrated in Figure 7, as is well known, there are a number of common control channels in the downlink which are commonly broadcast by the network; such channels typically include a broadcast channel BCH, a forward access channel FACH and a paging channel PCH.

The BCH is used to provide cell-specific information, such as the cell identity and the available short and long codes for random access channel RACH transmission; information about neighbouring cells can also be provided. In the majority of cell scenarios the information carried by the BCH

can be assumed to be static for the duration of most telephone calls.

The FACH is primarily used to carry initial call set-up control information to a mobile when the system knows the location cell of the mobile. The FACH can also carry short intermittent packet information.

The PCH is used to carry information primarily to initiate network originated calls, eg from a landline telephone, to a mobile station when the system does not know the location cell of the mobile. The PCH may have a ▒ sleep mode▒ when traffic is low.

These and other common control channels are separated from one another by channelisation codes, and possibly also be fixed time-offsets.

In the arrangement there is no common pilot channel, therefore each channel in addition has its own dedicated pilot symbols which are embedded at regular intervals between the transmitted data symbols.

In the present invention a mobile 12 utilises the pilot symbols in existing common downlink channels in addition to the pilot symbols provided by its own dedicated pilot channel or channels. By use of such a combination decreased energy is required in the dedicated pilot channel of the mobile.

Figure 8 shows the energy flows. The pilot channel of the mobile 12 is referred to as a hybridised common pilot channel HCPC 30, and pilot information from it flows through a first rake finger 32 to a channel estimator in two stages 34, 36. Pilot information from at least one of the downlink channels, indicated at 38 as a dedicated traffic channel, passes through a second rake finger 40 to the channel estimators 34, 36. (Although two sets of rake fingers are shown, in practice only one may be needed). The output of the estimators 34, 36 passes to a conjugate multiplication stage 42 which also receives input directly from the dedicated traffic channel, and then to a maximum ratio combining stage 44. The output of the combining stage, connected to the processor of the mobile, indicates channel impulse response of the mobile's receiver, and permits use within the mobile of coherent detection techniques.

The channel estimation functional units 34,36, are shown in two stages to indicate the possibilities of:

i) Combining in stage 34 the de-spread pilot symbol energy from the dedicated traffic channel and Hybridised Common Pilot Channel sources to create effectively a single pilot source which is then used to estimate the extent of channel distortion in stage 36;

ii) Independently calculating channel estimates from the two despread pilot symbol sources in stage 34 and then combining the two resultant sets of channel estimates in stage 36.

The channel estimates produced by the channel estimation functional units 34,36 are used by the conjugate multiplication stage 42 to mitigate the effects of channel distortion on the desired de-spread signal using coherent detection.

The use of information from at least one broadcast channel allows lower pilot energy input through the hybrid channel, i.e. in figure 2, E_p can be reduced.

Usually there will exist an almost continuous stream of pilot symbols from of the available downlink several common

control channels such as the BCH, FACH and PCH. Since all the channels experience the same channel conditions, the mobile can obtain accurate and robust multi-path tracking information, as well as channel estimates.

The energy flow arrangement illustrated in Figure 8 applies when there is a non-zero offset between the two sets of pilots; the parallel receiver structure allows the two sets of pilot symbols to be demodulated in parallel.

If there is no time offset between the two sets of pilot symbols, parallel pilot symbol energy flows such as illustrated in Figure 8 will not be necessary, and a sub-set of existing rake fingers can be allocated to demodulate just the multipath components which are deemed to require extra robust ▒ channel estimation▒ ; this requires additional rake finger management.

A typical mobile 12 is shown in Figure 9. It has a RF transceiver 50 connected to a baseband demodulator 52 which passes control data to a control signal process of 54 and data signals to a decoder connected to a user data processor 58.

A further reduction in pilot energy can be achieved by incorporation of base station (BTS) intervention. The mobile 12 is arranged to provide feedback signals to the BTS about the quality of its HCPCH, ie the noise or power or phaseb rotation of the pilot symbols. The BTS can then reduce the power of the pilot symbols in the mobile's dedicated pilot channel in comparison with the power of the data symbols. A further advantage of such a power variation is that, depending on the cell scenario, it will reduce the overall power transmitted by a BTS on the downlink, which for a multi-user CDMA system (Fig.7) improves the downlink capacity.

To provide BTS intervention, additional parts of the mobile 12 are affected; referring to Figure 9, the control data processor provides the required information to the BTS by a loop to the base band demodulator 60 in the mobile, its output being connected to the RF transceiver 50.

A yet further improvement is provided by adapting one of the common channels, using the BTS intervention arrangement described above. The channel and tracking estimation stages, 34, 36 in Figure 8, are arranged to estimate the performance gains from the HCPCH; this performance gain can be improved by adapting the time-offsets between the pilot symbols belonging

to the common channel(s) being used to generate the HCPC and the pilot symbols transmitted on the dedicated traffic channel(s) to suit channel conditions. In most circumstances it will be preferable to have the HCPCH pilot aligned in time with the DTCH to simplify the channel estimation combining process represented by 34,36. However, in some circumstances, e.g. when the channel is varying very quickly, it will be preferable to have the HCPCH pilots occurring half-way between DTCH pilots; this can significantly improve multi-path tracking performance.

Such an arrangement affects a base station BTS; a typical arrangement is shown in Figure 10 in which a mobile 70 is connected to a BTS 72 which is controlled by a RNC 74. The RNC 74 controls the timing of the pilot symbols in the common channels which provide inputs as dedicated traffic channel energy in Figure 8, and can therefore vary the timing of the symbols with respect to the dedicated pilot channel symbols, as required.

Instead of shifting the timing of the pilot symbols in the common channels, in another variation the RNC 74 can be arranged to substitute pilot symbols for data symbols on common channels such as the FACH or PCH to create Extended

HCPC (EHCPC) channels. Doing this trades-off common channel capacity (eg the number of calls that can be set up or acknowledged in a unit of time) for improved channel estimation at a mobile.

Alternatively without the need for RNC intervention, the mobile can use the effectively static data symbols ona common channel such as the BCH as pilot symbols to create EHCPC. A mobile must always listen to such a channel for new calls, or for a paging service message, and such channels are rarely congested.

Claims

1. In a code division multiple access mobile radio channel communications network, a method of providing pilot symbols comprises providing a first set of pilot symbols through a plurality of pilot channels, each such channel being dedicated to one mobile user; simultaneously providing a second set of pilot symbols through at least one common control channel; and in a mobile combining the first and second sets of pilot symbols and from said combination estimating the channel impulse response.

2. A method according to claim 1 in which the common channel is one of a broadcast channel or a forward access channel or a paging channel.

3. A method according to claim 1 or claim 2 in which the pilot symbols from all common channels are combined.

4. A method according to any preceding claim further comprising combining static data transmitted on at least one of the common channels with the first and second sets of pilot symbols.

5. A method according to any preceding claim comprising transmitting from a mobile to a network base station information relating to quality (?) of received pilot

symbols, the base station then varying the energy associated with the first set of pilot symbols supplied to that mobile.

6. A method according to claim 5 further comprising the step of varying the time offsets between the radio frames in the dedicated pilot channel and the at least one common channel.

7. A code division multiple access mobile radio telecommunications network comprising a plurality of mobiles each having a dedicated pilot channel; a plurality of base stations; first pilot symbol generation means arranged to supply pilot symbols to the dedicated pilot channels; second pilot symbol generation means arranged to supply to at least one common control channel dedicated pilot symbols embedded between data symbols broadcast by the common control channel; and in each mobile, receiving means arranged to receive pilot symbols in the dedicated pilot channel and the common control channel, combining means to combine the received pilot symbols, channel estimation means to receive the combined pilot symbols, and coherent detection means arranged to vary at least one property of the mobile in accordance with the output of the channel estimation means.

8. A network according to claim 7 in which each mobile is arranged to send to an associated base station information relating to the quality of pilot symbols received on its dedicated pilot channel, and each base station is arranged to vary the energy of said pilot symbols accordingly.

9. A network according to claim 8 in which each mobile is further arranged to send to an associated base station information relating to the quality (?) of pilot symbols received on the at least one common channel, and each base station is arranged to vary the time-offsets between radio frames of the dedicated traffic channel accordingly. n

10. A mobile for use in a code division multiple access radio telecommunications network comprising first receiving means to receive pilot symbols on a dedicated pilot channel; second receiving means to receive pilot symbols on at least one common channel; combining means to combine said pilot symbols; and channel estimation means connected to the combining means to provide an output to coherent detection means.

11. A mobile according to claim 10 further comprising a set of rake fingers arranged to receive the combined pilot symbols.

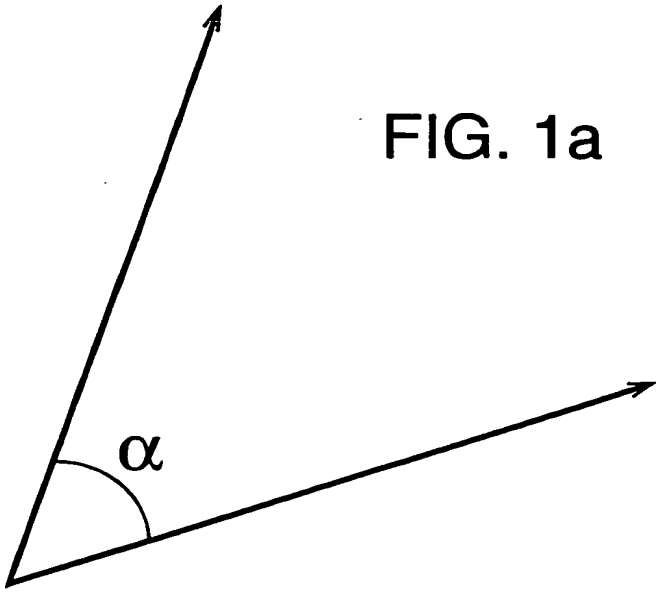


FIG. 1a

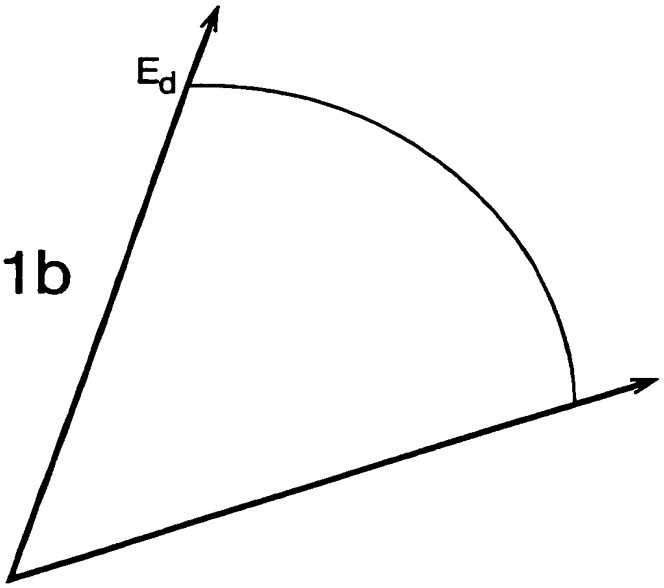


FIG. 1b

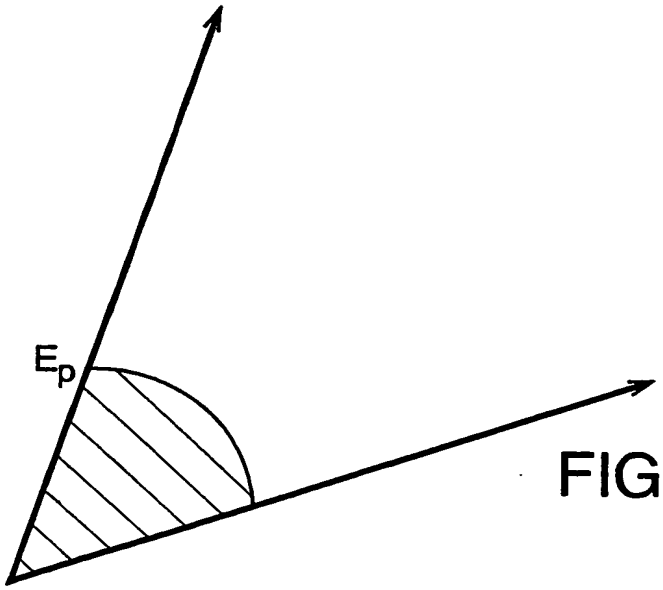


FIG. 1c

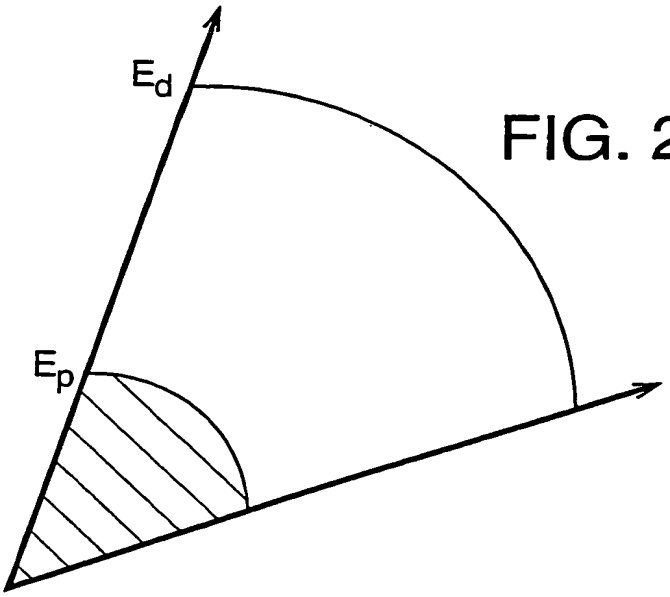


FIG. 2

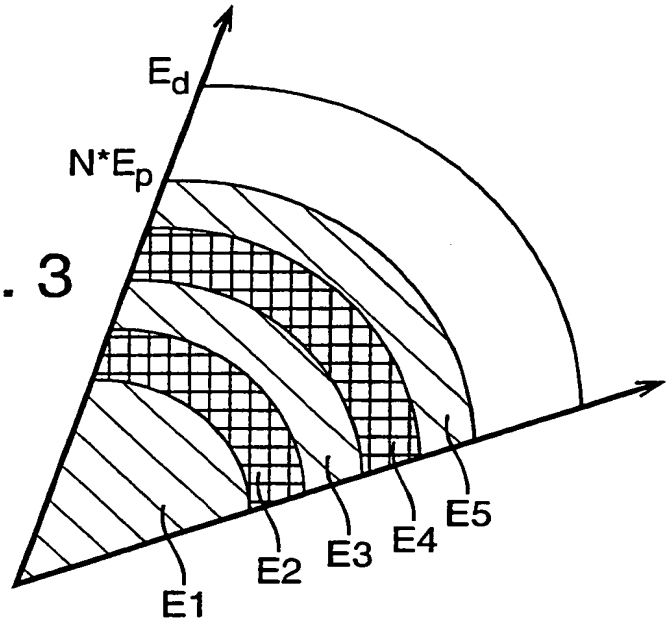


FIG. 3

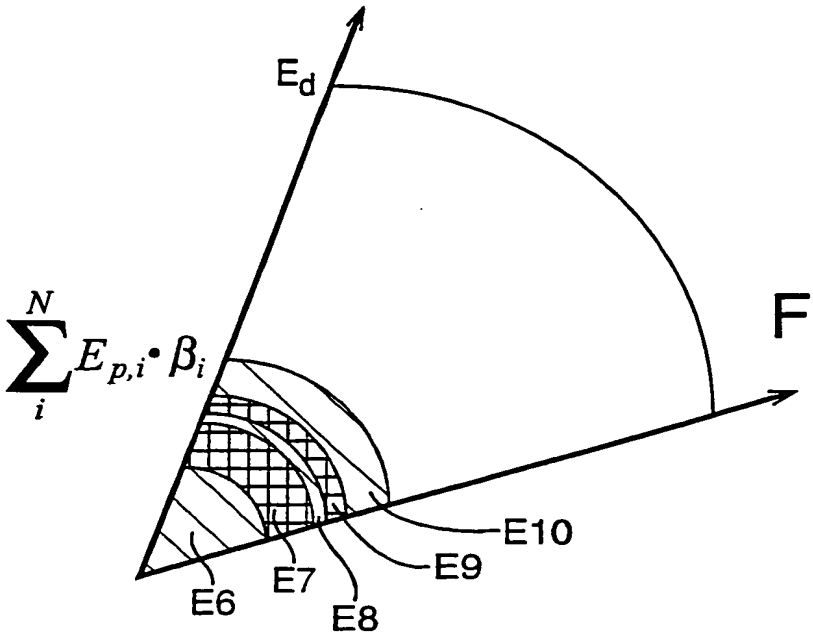


FIG. 4

FIG. 5

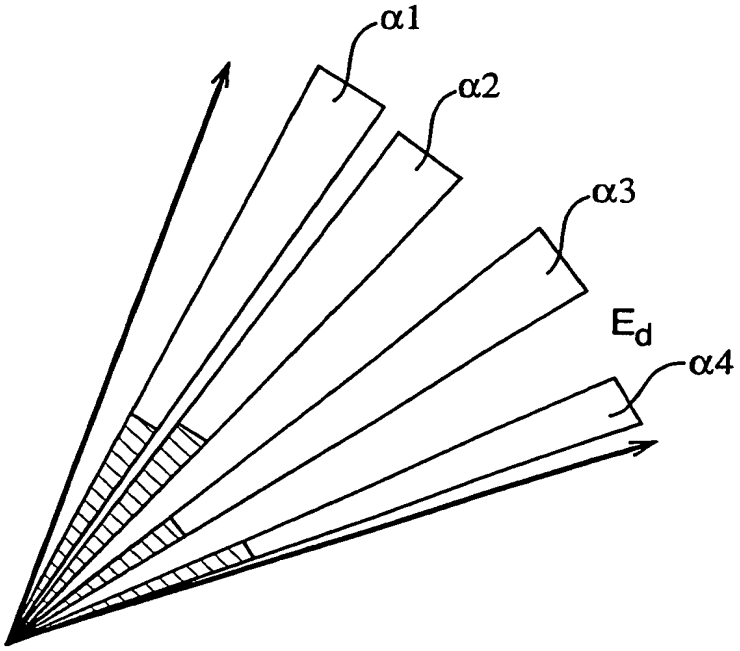


FIG. 6

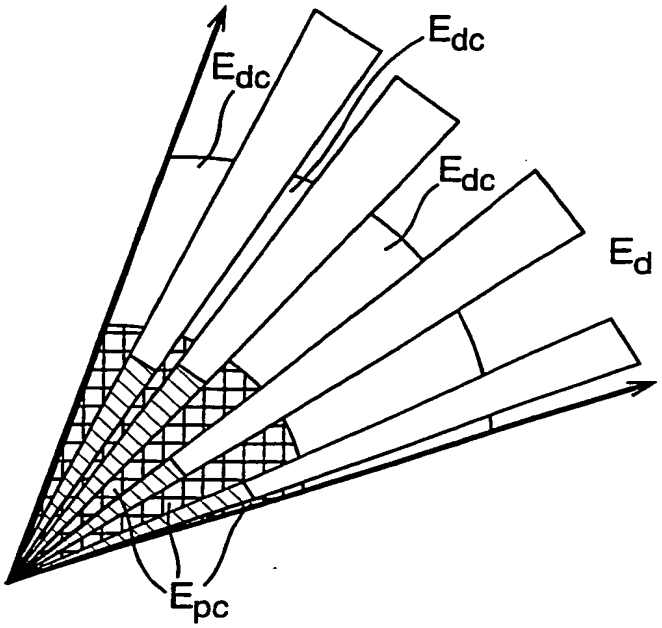
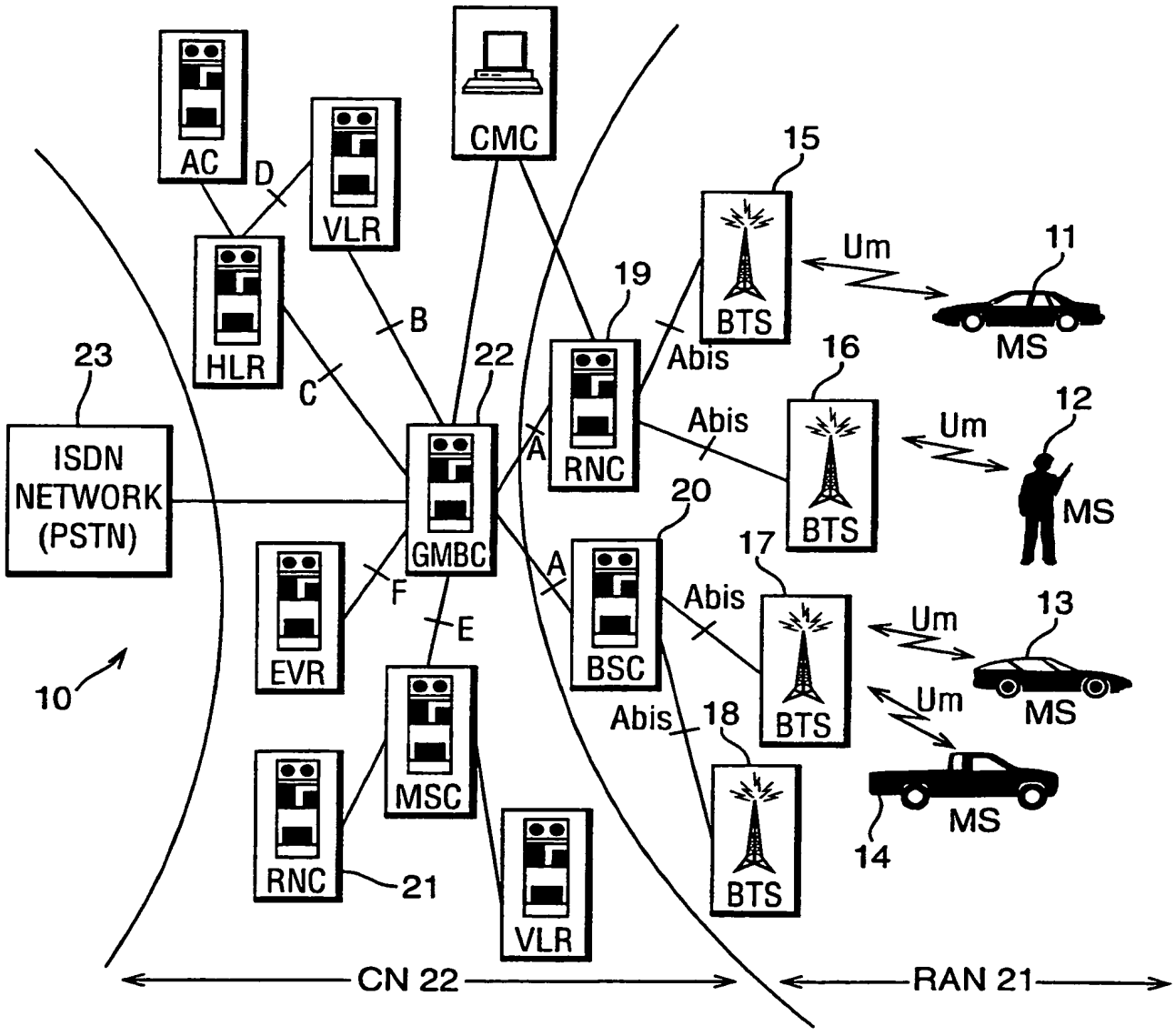


FIG. 7


AC
D
VLR
CMC
15
HLR
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19
Um
11
BTS
MS
23
C
22
Abis
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(PSTN)
A
RNC
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GMBC
17
A
Abis
Um
13
EVR
F
BSC
BTS
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10
E
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18
Um
MSC
MS
BTS
14
RNC
21
VLR
CN 22
RAN 21

FIG. 8

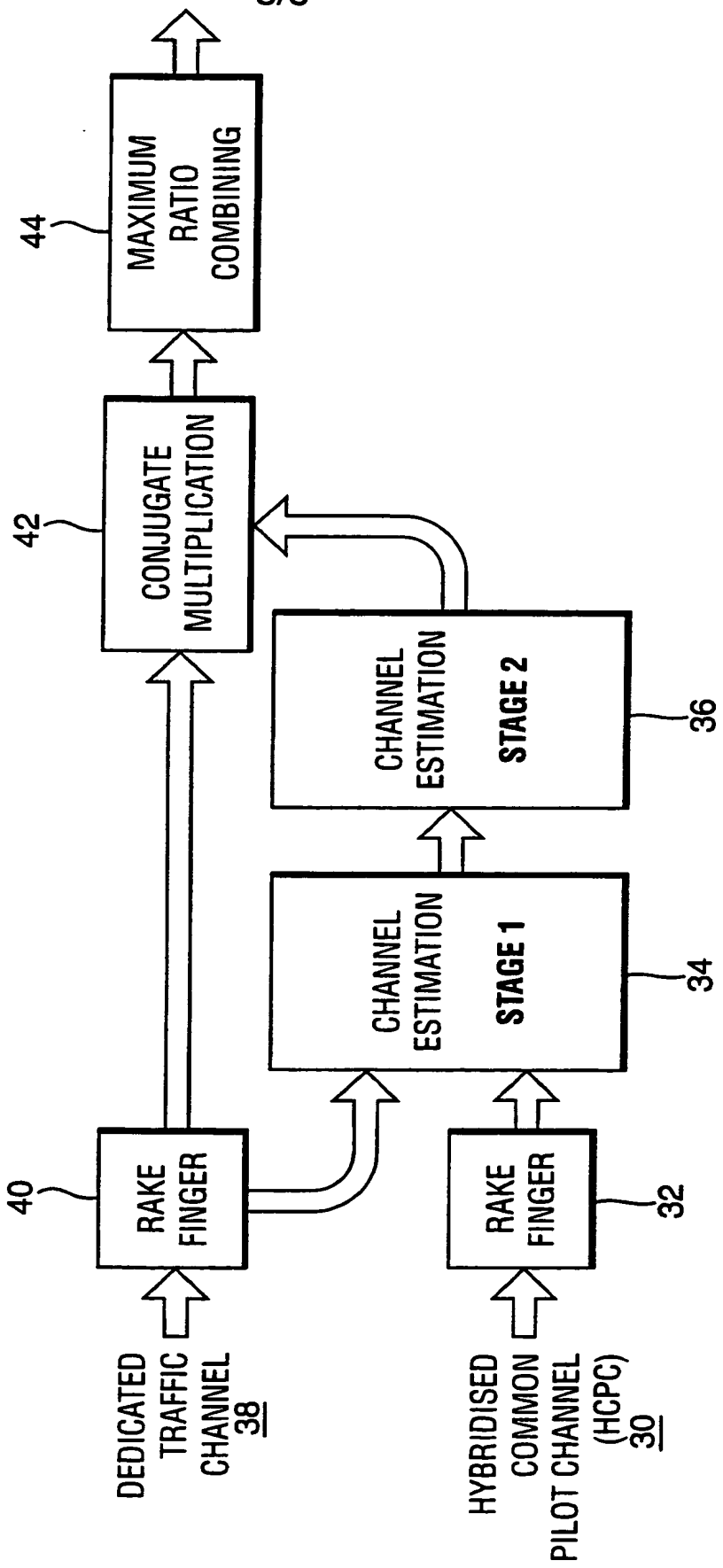

MAXIMUM RATIO COMBINING
44
CONJUGATE MULTIPLICATION
42
CHANNEL ESTIMATION STAGE 2
36
CHANNEL ESTIMATION STAGE 1
34
RAKE FINGER
40
RAKE FINGER
32
DEDICATED TRAFFIC CHANNEL 38
HYBRIDISED COMMON PILOT CHANNEL (HCPC) 30

FIG. 9

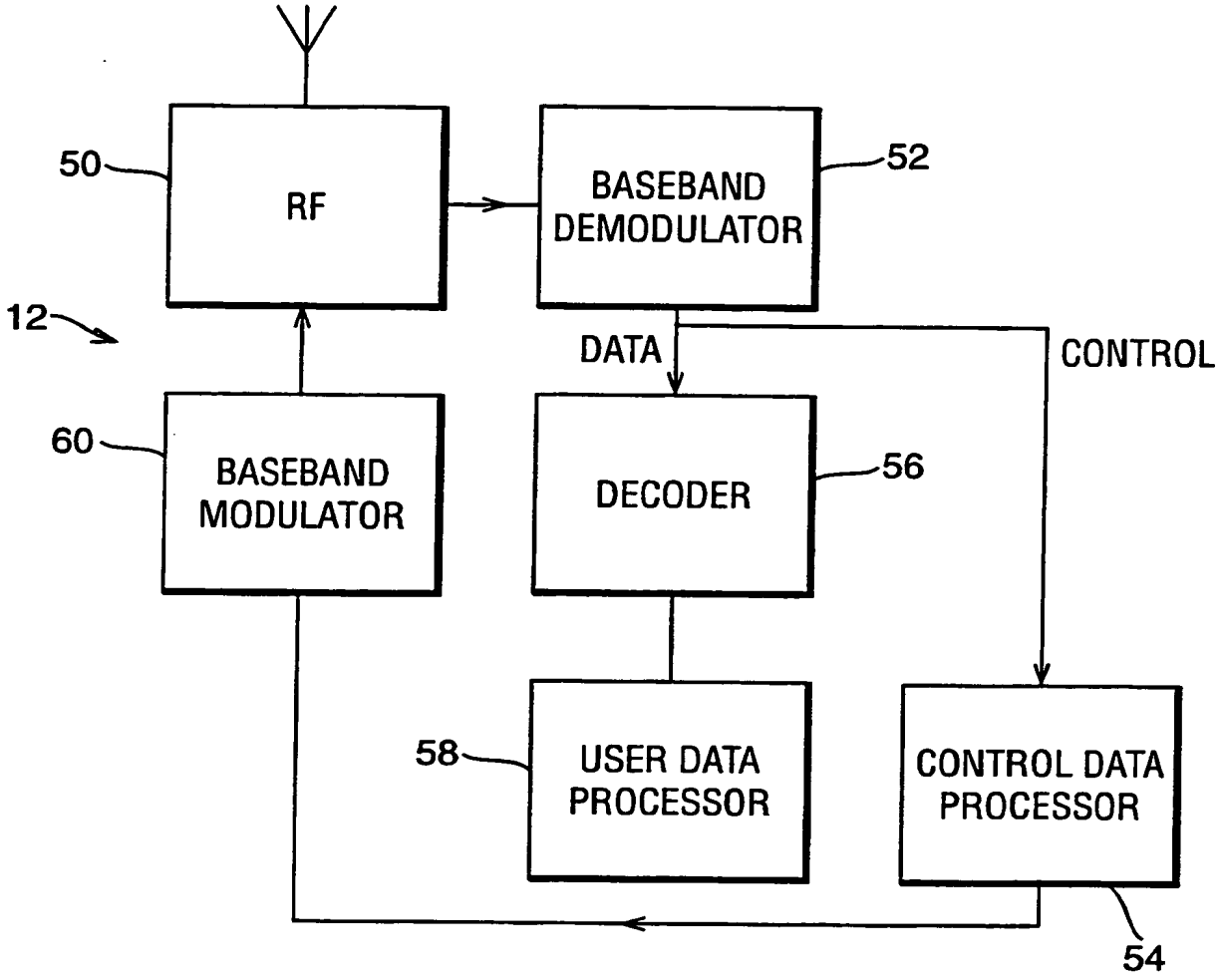
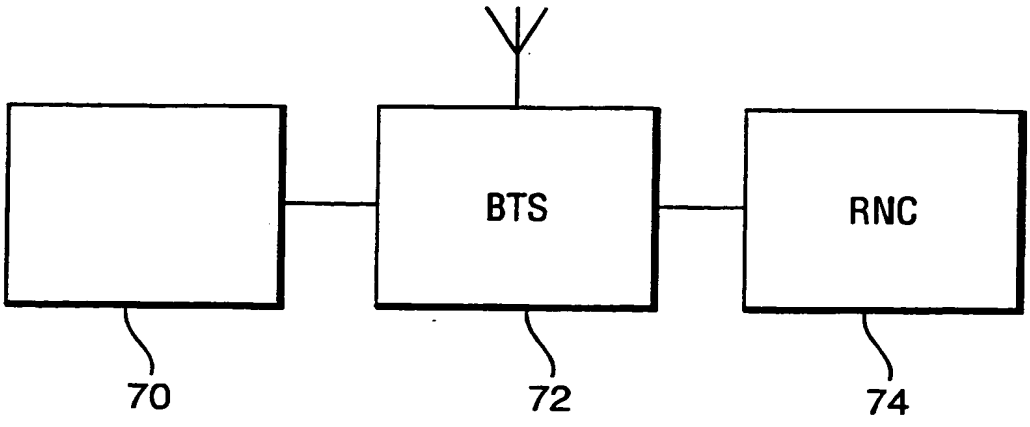

50
RF
BASEBAND DEMODULATOR
52
12
DATA
CONTROL
60
BASEBAND MODULATOR
DECODER
56
58
USER DATA PROCESSOR
CONTROL DATA PROCESSOR
54

FIG. 10


BTS
RNC
70
72
74

INTERNATIONAL SEARCH REPORT

Interna[redacted]plication No
PCT/EP 00/05098

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04B1/707 H04B7/005 H04L25/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04B H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 795 969 A (MATSUSHITA ELECTRIC IND CO LTD) 17 September 1997 (1997-09-17) abstract column 3, line 41 -column 4, line 26 column 5, line 21 - line 56 column 8, line 8 - line 47 ---	1,7,10
A	DATABASE WPI Section EI, Week 199920 Derwent Publications Ltd., London, GB; Class W02, AN 1999-239899 XP002124380 & JP 11 068700 A (NEC CORP), 9 March 1999 (1999-03-09) abstract --- -/--	1,7,10

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
2 October 2000	19/10/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Lustrini, D

2

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INTERNATIONAL SEARCH REPORT

Information patent family members

Application No
PCT/EP 00/05098

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	ABETA S ET AL: "PERFORMANCE COMPARISON BETWEEN TIME-MULTIPLEXED PILOT CHANNEL AND MOBILE RADIO. PARALLEL PILOT CHANNEL FOR COHERENT RAKE COMBINING IN DS-CDMA" IEICE TRANSACTIONS ON COMMUNICATIONS,JP,INSTITUTE OF ELECTRONICS INFORMATION AND COMM. ENG. TOKYO, vol. E81-B, no. 7, page 1417-1425 XP000790175 ISSN: 0916-8516 abstract paragraph '0003! ---	1,7,10, 11
A	US 5 862 453 A (LOVE ROBERT T ET AL) 19 January 1999 (1999-01-19) abstract column 2, line 14 -column 3, line 21 -----	5,8

2

7/2/99

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Zeichen/Ref./Réf.	Anmeldung Nr./Application No./Demande n°./Patent Nr./Patent No./Brevet n°.
D.BHATOOLAUL 4-16	99305246.3-2211-

Anmelder/Applicant/Demandeur/Patentinhaber/Proprietor/Titulaire
LUCENT TECHNOLOGIES INC.

COMMUNICATION

The European Patent Office herewith transmits as an enclosure the European search report for the above-mentioned European patent application.

If applicable, copies of the documents cited in the European search report are attached.

☐ Additional set(s) of copies of the documents cited in the European search report is (are) enclosed as well.

The following specifications given by the applicant have been approved by the Search Division:

☒ abstract ☒ title

☐ The abstract was modified by the Search Division and the definitive text is attached to this communication.

The following figure will be published together with the abstract: 8

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REFUND OF THE SEARCH FEE

If applicable under Article 10 Rules relating to fees, a separate communication from the Receiving Section on the refund of the search fee will be sent later.

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 99 30 5246

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	EP 0 795 969 A (MATSUSHITA ELECTRIC IND CO LTD) 17 September 1997 (1997-09-17) * abstract * * column 3, line 41 - column 4, line 26 * * column 5, line 21 - line 56 * * column 8, line 8 - line 47 *	1,7,10	H04B1/707 H04B7/005 H04L25/02
A	DATABASE WPI Section EI, Week 199920 Derwent Publications Ltd., London, GB; Class W02, AN 1999-239899 XP002124380 & JP 11 068700 A (NEC CORP), 9 March 1999 (1999-03-09) * abstract *	1,7,10	
A	ABETA S ET AL: "PERFORMANCE COMPARISON BETWEEN TIME-MULTIPLEXED PILOT CHANNEL AND MOBILE RADIO. PARALLEL PILOT CHANNEL FOR COHERENT RAKE COMBINING IN DS-CDMA" IEICE TRANSACTIONS ON COMMUNICATIONS,JP,INSTITUTE OF ELECTRONICS INFORMATION AND COMM. ENG. TOKYO, vol. E81-B, no. 7, page 1417-1425 XP000790175 ISSN: 0916-8516 * abstract * * paragraph '0003! *	1,7,10, 11	
A	US 5 862 453 A (LOVE ROBERT T ET AL) 19 January 1999 (1999-01-19) * abstract * * column 2, line 14 - column 3, line 21 *	5,8	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)
H04B
H04L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	30 November 1999	Lustrini, D

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 99 30 5246

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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30-11-1999

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